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Governance over Wastes All Round the Universe

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Abstract—*Our universe is enormously huge and every human being should have a motto to keep it clean. The management of waste has become the need of the hour. Of all wastes, nuclear waste should be given the utmost priority as it has a lethal impact on environment. Nuclear waste is generated when Thorium, Uranium or Plutonium atoms collide with a neutron and disintegrates into 2 or more parts. The disposal of nuclear waste into space is a very profitable option. Space shuttle along with an Orbit Transfer Vehicle may be used to transport nuclear waste. Nuclear waste is not only the problem for the whole world but also for the Nuclear Power Industry. Also nowadays, Space Debris has become a serious topic for discussion. Space Debris may be defined as a human made object present in space which is obsolete and useless. It has become a torment for space missions as it may collide with costly spacecraft. Guidelines should be established for debris mitigation & debris removal. There are 3 steps for waste disposal in space. Firstly, the waste should be transported to the launch site. Secondly, launching in low orbit should be done. Eventually, launching should be done to a final destination which includes solar orbit inside Venus, Earth-moon liberation points, lunar landings and outside solar system. This study will only succeed when all the countries work together for the safety of the whole world. This may result in world harmony. This may be one of the reasons to integrate the world & fight against a serious future problem. The supreme purpose of this study is to identify additional destination, Space Transportation System for disposing waste in space such as nuclear waste and methods to collect space debris & minimize it.*

1. INTRODUCTION

It should be taken into consideration that nuclear waste can be put in a container or can be solidified or can be immobilized & moved but we can't make it go away.

There are many procedures followed nowadays for the depletion of waste present in the space and preventive measures are also taken so that waste is not directly dumped into the open space which controls the pollution in the outer world. One of these methods is Waste Collection System (WCS) on Space Shuttles.

Waste Collection System (WCS) on Space Shuttles is done using Space Toilets. It uses rotating fans to distribute solid waste for in-flight storage and air flow too. Solid waste is first distributed in a container which is cylindrical in shape followed by exposing it to vacuum for drying purpose of the waste. Liquid waste are directly thrown away to space as these are very less harmful for the universe.

A space toilet, also known as zero gravity toilet, is a toilet that is used especially in a weightless environment like moon or space. Due to absence of weight, the collection and retention of liquid and solid waste is done by using fans for forced air flow so that a suction and pressurised air sucks the waste or pushes the waste to container tank respectively. The air used to direct the waste which is returned to the cabin is primarily filtered to control the odour and cleanse the bacteria which is present in the waste. In older systems, waste water is sent out directly into space, and any solids present are kept at low pressure and stored for removal after its landing. Modern systems have come into play which expose solid waste to pressures lower than surrounding pressure i.e vacuumed for demolition of bacteria, which prevents odour problems and destroys all the pathogens too.

There are other ways also for control of pollution in the outer world.

2. DEALING WITH DEBRIS

For the past 50 years, manmade space debris has been reducing out of orbit at a rate of about one object per day. After every 11-year solar cycle a variation in the average rate occurs due to heating (and thereby expansion) of the Earth's atmosphere, averaging almost three objects per day at solar maximum and usually five and one-half years later which is called solar minimum, the average becomes one again about every three days.

Corporations, academics and government agencies have invented and found out innovative plans and technology to deal with space debris as natural decay of space debris has dangerous atmospheric effects. So, it is high time to take care of these debris for the betterment and well-being of atmosphere. But unfortunately, most of the technological approaches have not yet become funded projects and there is no business plan extant to reduce the amount of space debris till date.

There are 6 basic ways of dealing with space debris:

- Growth mitigation - For reduction of future space debris, the passivation of spent upper stages is done by the release of residual propellants which reduces the risk of orbital explosions followed by generation of additional

debris. The renovation and changes in the Delta boosters abolished their contribution to the trouble.

- Self-removal - Passive methods are done for increasing the orbital decay rate of spacecraft debris. An electrodynamic tether is attached to a spacecraft at launch instead of rockets. Then, the tether rolls out to slow the spacecraft at end of its lifetime. Booster stage with a sail-like attachment and a large, thin, inflatable balloon envelope are also different methods for self-removal.
- External removal - A tug-like satellite is used for dragging of debris to a safer altitude for it to burn up in the atmosphere. When debris is identified, the satellite creates a potential difference between the debris and itself, then using thrusters it moves itself along with debris to a safer orbit.
- Extreme compaction - The total food-related waste around the space is around 8,600 pounds and other commodities such as disposable clothing, paper and body towels accounts for around 5,200 pounds. It's a huge amount of weight to launch and store in a spacecraft. To help this process both wet and dry waste a Heat Melt Compactor was created by NASA. Waste is heated to 320° F in the system and are be compacted into discs which are roughly one-inch-thick and eight inches in diameter. Heating of trash for drying, sterilizing and melting any plastic are some of the process done inside the compactor. The machine compacts and melts it to form a solid rigid tile which does not expand, if the plastic content inside the refuse is more than 20 percent. The compressed trash is then cooled followed by removal of waste tile. The trash tile has a dual purpose, it can be used as a shield that may protect astronauts from solar flares and radiation as well as it helps in shrinkage of trash's volume.
- Space waste-to-energy – People have been working on NASA's Trash to Supply Gas project so that the waste which is present in the space can be utilised as a source of energy. This is a kind of study where the useless things are transformed into huge significant things which helps in the betterment of the universe. The waste-conversion technologies used here are primarily six - pyrolysis, gasification, combustion, ozonation, catalytic reduction and steam cracking. Though these are not developed and brought into practice, it will be brought into practice in the near future with the help of government fundings and all.
- Space clothes - Reuse is another facet which can be implemented for improving waste in space. Instead of cotton-based materials, the Advanced Clothing Systems looks at ways to create astronauts' clothes from polymers. Clothing plays a vital role as it decreases a significant portion of weight which is very much important on space missions. Clothes are discarded when it gets too dirty to wear because there is no availability of stuffs like space laundry or dry cleaning. There are a couple of benefits of having clothes made of a polymer rather than cotton-based fabrics. First, allow The clothes remain free from foul odour for longer period of time with the help of antimicrobial coatings which are combined with high-wicking and low-moisture retention and the second is it decreases the weight on shuttles and reduces the burden of its disposal.

There are many other methods too but these are the methods which can be implemented with optimum use of resources and government fundings.

3. LITERATURE REVIEW

Coopersmith (1999) investigated about the technological & non-technological matters involved with launching of high-level nuclear waste in space. He also concluded that different communities such as technical, scientific, political and economics should work all together for the success of safe space disposal. He mentioned about the Nuclear Waste Policy Acts of the United States. He also discussed about technologies such as Electromagnetic Launchers, Gas Guns, Laser Propulsions and Solar Sails & destinations such as Lunar Landings, Earth-moon liberation points etc.

Rao (2001) in his paper, dealt with the global problems which are arising due to radioactive waste. He discussed about the amount of waste generated and also proposed some solutions for it which he said must be taken into account by Government.

Mishra (1999) did a comprehensive study about the radioactive waste management in India. He discussed about characteristics of waste, its segregation, waste treatment, conditioning, storage and disposal.

Burns et al., (1978) wrote about the reason for nuclear waste disposal in space. They discussed about nuclear waste packaging like Waste Canister, Radiation Shield, Mechanical Containment, Thermal Protection System and Ejection System. They also discussed about the ground rules for transportation & launching of these waste. They enlightened the space transportation system requirements like OTV, Space Shuttle etc.

Hall (2014) said that the presence of space debris will become a future threat in space. Solutions are being discovered to minimize and remove it. Also it has some complex technologies involved and is very costly.

4. NUCLEAR WASTE

These are wastes that contain radioactive material, usually a by-product of nuclear power generation. It's dangerous for any sort of interaction for any life forms. Though it decays over time the period is too long for which it needs appropriate disposal. The most relevant actions have been its segregation and storage in various facilities. Surface disposal for low level waste and deep burying for high level waste. Medical and

industrial wastes count for low level and power plant wastes count for high level wastes.

Table 1: New Classification of solid and solidified radioactive waste (Source: International Atomic Energy Agency)

Sl. No	Waste Classes	Typical Characteristics	Disposal Options
1	Exempt waste (EW)	Activity at or below clearance levels, which are based on an annual dose to members of the public of less than 0.01 mSv	No radiological restrictions
2	Low and intermediate level waste (LILW)	Activity levels above clearance levels and thermal power below about 2kW/m3	
	Short-lived waste (LILW-SL)	Limitation of long-lived alpha emitting radionuclides 4000 Bq/kg per waste package	Near surface or geological disposal facility
	Long-lived waste (LILW-LL)	Long-lived radionuclides concentration exceeding limitations for short-lived waste	Geological disposal facility
3	High level waste (HLW)	Thermal power above 2kW/m3 and long-lived radionuclide concentration exceeding limitations for short-lived waste	Geological disposal facility

5. SPACE DEBRIS

Space or orbital debris are comprises of both remains of human made equipment or meteoroids orbiting around the Earth. More than 500,000 are currently tracked as they move around the Earth. Moving at high velocities they can easily puncture space vehicles and machines sent up for a purpose. This is a big danger for space shuttles. There is always a set of rules followed by space agencies before launching any satellite or space vehicle. This is done basically for the safety of the crew and the machine. Debris though has no useful purpose contains rather expensive space craft parts, launch stages and mission relevant scrap.

Constantly having 500,000 tracked parts of debris varying from sizes of about a marble to a softball is a relatively humble issue considering the various other non-tracked debris on the outer orbits. Non-traceable debris accounts for the maximum risk taken on missions. Debris wrecked machines further add considerable amount of debris into the space junkyard.

Tracking debris is a fairly advanced concept. NASA and US Department of Defense have very accurately managed to get a trace upon debris that are larger than softball. A collision risk characteristics has been done that mostly depends on the size. Upon the factors proper arrangements like debris shielding can done.

Guidelines to prevent impact generally draw an imaginary box around the space vehicle with the vehicle in the center. Any scope of near pass of debris is dealt with proper calculations and alignment of the machine. Such maneuvers are preplanned and path planning always has some possibility if debris impact, so, there is always a risk for crew or machinery. But the focus on proper avoidance has increased since the launch of the first elements of international space station.

Major debris zones lie in the 750-800 km mark above the Earth's surface but they do exist beyond the 2000 km mark. As there is no existing technology adept enough for its removal, the space crafts have to rely on heavy shielding. Debris tend to stay on orbit for a really long time. Scrap below the 600 km mark usually fall down within years, beyond the 1000 km mark and they stay there for centuries. For such reasons the best action right now is reducing the creation of debris which can be achieved via effective design and high quality operation.

Increasing need of space based resources has led to creation of new laws regarding space junk that has always been an increasing factor of security. Various space agencies have their specific rules but there is no international treaty yet.

6. SOLAR SAILS

Basically a low thrust propulsion system, it is used to push ultra-thin mirrors to high speeds. It's a low cost operation system with sustaining life. Since there is no use of propellant they can be used many times for interstellar transport.

7. NUCLEAR REACTION

It is a process in which two nuclei or an atom and subatomic substance from its outside are collided to produce one or more nuclides that are not similar. Meaning, the reaction helps transform of at least one nuclide to another. Basically there is change produced in the nuclide. Nuclear reactions can be both natural or artificial, either interaction with cosmic rays and matter. Two basic ways to get to a nuclear reaction are either fission or fusion. Gamma emissions and alpha decay are also notable types.

8. SPECIFIC REMOVAL METHODS

Long-Term debris environmental forecasts only show the rise in its levels. Rise in levels will also be mostly due to collisions. Removal methods are only concepts and their use requires international cooperation. Some of them are:-

1. LASERS: High power lasers can be used from earth to nudge the debris away from launch trajectory. Laser generators need to produce beams with nominal powers

on poles taking benefit from the surrounding thin atmosphere.

2. CleanSpace One: These will be debris holders that will go into space to retrieve high priority satellite systems. Once in space they will need to capture the priority and head back into earth's atmosphere. Swiss research organization EPFL (École Polytechnique Fédérale de Lausanne) has effectively utilized a folding conical net to gulp up bits of debris. Dimensions of target and its speed will be top factors that will be accounted for.
3. Space Nets: Japanese aerospace agency has proposed a theory that utilizes the concept similar to fishing nets. A thin net like material moves around in space collecting debris and it then has to pulled back into earth burning up all contents along with it. This concept appears to be science fiction for now but proper blueprints have already been established for such a device.

9. CONCLUSION

Through research and experience an understanding is made out of the current situation. It can be clearly seen that the rise in the number of debris doesn't pave the way for sustainable space which is very important for the continuum of our future generations. Procedures followed by space agencies needs to be re-established with a more inclusive, coherent and practical approach. Reducing number of debris is a need that can only be worked out with the involvement of the total international community. Agencies have to practice an efficient system that improvises on plan because of the many solutions suggested only few prove to be viable in terms of technological limitations. Problems have to be framed and the solutions need to be worked out.

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